STATUS OF AGRICULTURAL MECHANIZATION IN ALRAHAD, NEW HALFA AND GEZERA SCHEMES

By

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DEDICATION

To of my father.

To my mother.

To my brothers and sisters.

To all my best friends

To everyone who contributed to my education.

Mwahib

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Abstract

The objectives of this thesis are to assess and study the status of the agricultural mechanization in ALrahad, NewHalafa and Gezira schemes.

A field survey was conducted in July /2009 using stratified random sampling design. 399 Farmers, agricultural engineers, operators and technicians were interviewed. The data was coded and statistically analyzed using SSPS cross tabulation.

The descriptive analysis showed that, in the farmer's community, percentage of illiteracy, in the three schemes, was relatively low (12.0 %).51.2 % completed khalwa and elementary education, while 30.4% completed secondary education and 6.4 % followed university Education. (37.3%) of machine operators had experience of more than 6 years

As regards training, the analysis showed for the different categories in the three National Projects a complete absence of organized technical training. 76% of farmers 78.6% of operators and 52%of technicians did not receive any on-job training.

The study showed great variation in adoption of recommended technical package for the different crops in the three National schemes in all operations and there is a big gab between recommended and current practices and methods.

The analysis of mechanization situation for different crops in the three schemes showed that 75% of planting and 80% of harvesting operations mainly performed manual or semi mechanized.

مستخلص البحث

تهدف هذه الدراسة إلى تقييم ودراسة حالة الميكنة الزراعية في مشاريع حلفا الجديدة، الرهـد والجزيرة.

اجرى بحث ميداني وسط مزارعي ومشغلي الآليات والمهندسين الزراعيين بالمشاريع الثلاثة بإستخدام طريقة العينة كاملة العشوائية.

اختير مجموع 399 عينة وشفرت المعلومات وحللت إحصائياً باستخدام الـ SPSS.

اوضح التحليل ان 12%من مزارعى المشاريع الثلاث اميـون و51.2% اكملـوا الخلـوة والتعليم الاساسى بينما 30.4% اكملوا الثانوى و6.4% التعليم الجامعى. اشارت الدراسـة ان الخبرة العملية لمشغلى الالات والمزارعين تزيد على 6 سنوات. بالرجوع لبرنامج التدريب للمزارعين ومشغلى الاليات الزراعية نجد غيابا تاما للبرامج التدريبية اثناء الخدمة . اوضحت الدراسة ان 76% من المزارعين و78.6% من المشغلين 52% من الفنيين لم يحصلوا على اى تدريب اثناء الخدمة .

اشارت الدراسة الى تباين كبير فى توطين التقانات وجهل تام بالحزم التقنية لكل المحاصيل إذ تختلف العمليات الزراعية اختلاف كبير عن توصيات البحوث الزراعية.

اشارت الدراسة ان 75% من عملية البذر و80%من عمليات الحصاد تتم يدويا او مميكنة جزيئا.

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CHAPTER ONE

Introduction

1.1. Agriculture in Sudan:

Sudan is the largest country in Africa with an area of about 2.5 million km². It is bounded by the Red Sea on the east and on other sides by nine African countries. Its topography is generally a broad plain; the climatic conditions vary between deserts in the north passing through savannah to wet equatorial forest in the south. Rainfall varies from none or rare in the hot arid north to more than 1500 mm in the wet tropics of mixed forest in the south, with plenty of sun shine. Sudan total population is about 39 million with a growth rate of 2.9 % per year, 25 % of the population being urban. Agriculture, being the main sector in the Sudanese economy, provides food, raw material for local industries and job opportunitities. It contributes 51.1% of gross domestic product and 75% of labor force and 22%of export exchange (Bank of Sudan, 2006). Its growth rate increased from 7.2% in 2005 to 8.3% in 2006. The total arable land in Sudan amounts to 84 million hectares, out of which only about 32 million are now utilized for cultivation and range lands. There are great potentials for increasing production of crops and livestock. The current water resources available in the country amount to about 30 billion cubic meters (bcm), these include rainfall share from Nile agreement 18.5(bcm), non -Nile streams and ground water.

1.2 Farming systems in Sudan

There are two main sectors in Sudan:

1.2.1 Irrigated farming sector

In the modern irrigated sector, which covers about 1.9 million hectares, farms are irrigated mainly from the Nile and its tributaries by surface or flow by pumps. It is dominated by large irrigation schemes which include, Gezira, New Halfa, Rahad, Suki, White Nile and Blue Nile schemes. In these schemes different kinds of tractors, agricultural implements, fertilizers and chemicals are used. The main crops grown are Cotton, Wheat, Sorghum, Groundnuts, Sugarcane and Sunflower.

In traditional irrigated farming system small holdings are irrigated from the Nile and Wadis (water ways) all over the Sudan. The total area cultivated in this sector is about 0.8 million hectares. Although the area is limited, the crops grown are of high value, e.g. vegetables and fruit trees. Animal drawn implements are used for land preparation and hand tools for planting, weeding and harvesting crops (Mohmoud, 1982).

1.2.2 Rain fed sector

Mechanized rain fed farming is mainly practiced in the central heavy clay soils with rainfall between 350 and 800 mm per annum. It was established in the mid forties during world war two to secure food supplies within the country.

The annual area covered is, on the average, about 8 million hectares. The main crops grown in this system are Sorghum, Sesame, Millet, and Sunflower. The main machinery used includes tractors (70-80 hp) and the wide level disc harrow with seed box. Recently, some private companies have introduced large tractors (more than 150 hp) and some heavy implements, e.g. heavy offset disc harrows and large seed drills. The average farm size varies between 200 and 400 hectares with larger areas allotted to private companies.

The traditional rain fed farming is the largest agricultural sub sector in

Sudan and most of rural people are producers in this system. This system is largely confined to 350-800 mm rainfall region. Subsistence agriculture was practiced but now more cash crops are grown. The most important crops grown are Cotton, Millet, Sorghum, Sesame and Groundnuts, Gum Arabic. Most of the livestock is herded in this system. Cropped area varies from 5 to 8 million hectares annually. Rainfall being the governing factor. In this system hand tools and animals drawn implements are used for cultivation, harvesting and transportation. Since the average farm size is usually small (about 2 ha), the immediate introduction of powered large machinery will not be feasible (Mohmoud, 1982).

1.3 Research Problem

The performance of the agricultural sector is based on land productivity as function of water, labor and improved efficient technology. In spite of the fact that the productivity of some crops has improved, the productivity of many other important crops registered adecline compared to the productivity obtained in local research institutions and in other countries of similar conditions.

The efficiency of the existing agricultural schemes is low compared to their potential capacities. The scope of inefficiency is manifested in the following:

1. Low productivity.
2. High cost of production.
3. Stagnating farming system, shown in form of lack of adoption of new technologies.

Average productivity of Sorghum is around 255 kg per feddan for the period 1994-2003 (report of Green Mobilization high advisory committee); this is very low compared to high productivity obtained in countries like Argentina. Sorghum productivity in the Sudan is about one sixth of the

productivity in these countries. It is also only 45% and 37% of the productivities in Nigeria and Yemen respectively. Crops yield variability is a pronounced phenomenon in the irrigated schemes including Gezira, New Halfa and AlRahad Schemes due to difference in management practices and low mechanization levels (Mohmoud, 1982).

1.4 Research Objectives

The main objectives of this research work are:

1. To evaluate the current agricultural mechanization status in Gezira, New Halfa and AlRahad Schemes as related to the recommended technical packages for the main crops (Cotton, Sorghum, Groundnut and Wheat).

2. To assess the capacity (training) of the stakeholders (personnel &farmer) to improve performance.

CHAPTER TWO

LITERATURE REVIEW

2.1 Agricultural Mechanization

Farm mechanization is important and fundamental for agricultural development in any country. The main objective of mechanization is to decrease the difficulties of agricultural operations and to maximize production. Agricultural mechanization has been receiving considerable interest in recent time due to increasing food demand for the increasing population. Agricultural tractors and equipment play an important role in increasing production through timeliness of agricultural operations and increased cropping intensity (Kepner et al. 1978). In developing countries, the number of tractors and modern agricultural machinery was well increased; there is also a growing awareness among the developing nations for the role of agricultural mechanization in increasing agricultural production, productivity and improving rural life. However, the facilities for the education and training of personnel at all levels to cope with new technology in agriculture are lagging behind. Effective application of research and development in agricultural machinery can only be realized from the commercial production, i.e., there should be transition from technically viable innovations to commercially successful ventures.

2.1.1 Mechanization objectives

Kepner et al. (1978) reported that mechanization of agriculture has the main following objectives:

1. To increase the productivity per agricultural worker.
2. To save labor (due to shortage of labor in critical times) and make operations more precise.
3. To improve timeliness of field operations, as each operation is sensitive to time and has to be started and completed within an optimum period of time.
4. To reduce production costs and increase economic returns to farmers.
5. To improve the working and living conditions of the farmer by reducing drudgery and making farm work less arduous and more pleasant.

2.2 Farm Machinery Management

Farm management deals with optimization of the equipment use phases of agricultural production, repair, maintenance and replacement. Machinery management should be an important area of managerial concern because machinery cost is a large part of the total cost of operating a farm business. Control over machinery costs is accomplished by efficient use and management decisions regarding the number, type, size of machinery to be used, purchasing new or used machinery, and extent to which machinery requirement are met by leasing machines or hiring custom operator.

Kay (1981) defined machinery management as application of decision making principle to specific resource machinery with objective of increasing profits. Effective management of machinery is an important cost control in any farm management programme. Each machinery services decision will be decided by the farm resource needs and capability. Selection of the proper blend of machinery services will help ensure the total farm operation has a necessary and capital resource available to manage the farm effectively.

Machinery management has increased in importance in today's farming

operations because of its direct relation with success of mixing land, labor and capital to return satisfactory profit (Hunt, 1979). Appropriate agricultural mechanization should be based on rational acquisition, utilization and maintenance of machinery units and system to minimize operation costs and optimize performance in respective operations. The apparent low productivity of labor is major justification for appropriate mechanization application through human, animal and mechanical equipment in agriculture with regard to technical, socioeconomic and cultural constraints. As the size of farm continues to grow and machinery investments increase, efficient management of machines becomes more important to the success of an enterprise. Management includes determining the costs for performing particular operation, selecting the best size and type of equipment for each application matching machinery components in complete system, establishing an effective maintenance program, determining the optimum age for replacing particular machine, scheduling farm operations for the best use of machines. Computer analysis is becoming increasingly important in making certain types of machinery management decisions and is employed in some large farming enterprises (Kepner et al, 1978).

Hunt (1979) stated that proper machinery management requires knowing how to:

1. Keep records of fieldwork done by various machines and the working days available for critical field operations.
2. Estimate costs of machines and total cost of an entire system.
3. Know how to improve equipment reliability and work always towards elimination of unnecessary down time.
4. Improve field efficiencies of machines to cut costs and complete the work in the available time.

Good management may be used to reduce agricultural production and processing costs, which in turn may lead to lowering of commodity prices to allow fair competition between imports and locally produced commodities as secondary effects.

2.3 Farm Machinery Energy Requirement

The energy in agriculture is required for field operations which facilitate crop production and processing besides indirect energy in terms of seeds, fertilizer, irrigation, and chemicals. Human, animal, electrical and mechanical energy sources are extensively used in agriculture (Pan-Dey, 2003).

2.4 Machinery Field Capacity and Efficiency

The performance of agricultural machinery is measured by rate and quality at which operations are accomplished. Most agricultural field machine performance is reported as area per hour. Harvesting machines and processing equipments performance is usually expressed as bushels per hour, quintals per hour, tones per hour, and bales per hour in the case of balers, (Hunt, 1979). Field efficiency is the ratio between the productivity of machine under field conditions and the theoretical maximum productivity. Field efficiency isn't a constant for particular machine, but varies with the size and shape of the field, pattern of field operation, crop yield, moisture, and the field times. The following activities are considered as time loss in the field: turning and idle travels, material handling (seed, fertilizer, water and chemicals) harvested materials cleaning, logged equipment, machine adjustment, lubrication, refueling and operator loss time (Coates, 2002).

2.4.1 Theoretical field capacity (TFC)

Theoretical field capacity is the maximum capacity obtainable at a given speed with machine operating at its full width. The Theoretical field capacity of an implement is the rating of coverage that would be obtained if the machine is performing its function utilizing hundred percent of the time at the rated forward speed and always covering hundred percent of the rated width (Kepner et al. 1978).

Culpin (1976) reported that, theoretical field capacity is calculated simply by multiplying the distance traveled in an hour by the effective working width. Theoretical field capacity can be calculated by the following equation (Hunt 1979).

$$TFC = \frac{SW}{CF}$$

Where:

TFC ≡ Theoretical field capacity (ha/h).

S ≡ working speed (km/h)

W ≡ Actual cutting width of implement (m).

CF ≡ Conversion factor (10).

2.4.2 Effective Field Capacity (EFC):

Graham (2000) reported that, the Effective field capacity is the actual output achieved by machine. It is a function of proportion of the machine width utilized, the travel speed and the amount of time lost in the field during the operation. Time is lost to implement blockage, working areas such as headlands more than once, adjustments checking and minor repairs and excludes daily servicing requirement such as lubrication.

Effective field capacity can be calculated by the following equation (Hunt 1979).

$$EFC = \frac{SWE}{CF}$$

Where:

EFC ≡ effective field capacity (ha/h).

S ≡ travel speed (km/h).

W ≡ rated width of implement (m).

E ≡ field efficiency as decimal.

CF ≡ Conversion factor (10).

Effective field capacity is the actual rate of performance land or crop processed in a given time based upon total field time, (ASAE, 1983). Also it is defined as the actual rate of coverage by the machine, based upon the total field time (Kepner et al. (1978), said that for implements such as harrows, field cultivators and combines, it is be practically impossible to utilize the full width of the machine without occasional skips, which is a function of speed of travel, ground condition and skill of operator. Field time is an important factor that must be considered when measuring field capacity of any machine.

ASAE (1983) reported that, field time is the time a machine spends in the field, measured from start of an activity to the time the activity is completed. The field time includes the productive time and lost time, where, the productive time is the actual time that a machine spends in the field to achieve a specific operation. Kepner et al, (1978) stated that, lost time is the most difficult variable to evaluate in relation to field capacity. It may be lost as a result of adjusting or lubricating the machine, breakdowns, clogging, turning at the ends, adding seeds or fertilizer. The time lost does not include time for daily servicing for major repairs in the field.

2.4.3 Field efficiency (FE)

Field efficiency is the ratio of the effective field capacity to theoretical field capacity. It includes the effects of time lost in the field and failure to utilize the full width of the machine. Also field efficiency accounts for failure to utilize the theoretical operating width of the machine, time lost,

operator capability and habits, operating policy and field characteristic (shape, size patterns) (ASAE. 1983).

2.5 Selection of Farm Machinery

One of the most difficult tasks in farm management is proper machinery selection. Putting together an ideal machinery system is not easy. Equipment that works best one year may not work the next year because of the changes in weather condition or crop production practices. Improvement in design may make older equipment obsolete, and, the number of acres being farmed or the amount of labor available may change, (Edward, 2001).

2.5.1 Factors affecting size of machinery needed:

1. Area of crop: when large areas are farmed, large scale machinery is needed to insure that planting and harvesting are completed in time.
2. Labor supply: increasing the labor supply by hiring extra operators or by working longer hours during critical periods.
1. Tillage practices: amount of machinery is determined by the number of field days available for each operation.
2. Crop mix: diversification of crops tends to spread out the periods when timely completion of field operation is critical.
3. Weather: the number of working days governed by weather condition.
4. Risk management: fluctuation in the number and sequence of suitable field days from year to year because timeliness cost vary even when the machinery set, number of crop acres and labors supply do not change.

Kay (1981) enumerated the factors that have important influence on the selection of one machine in comparison to an other as:

1. Trademark: It is distinguished mark, device or symbol affixed by a manufacture merchant, or trader to his goods in order to identify them

as his goods and distinguish them from the goods manufactured, sold, or dealt in by other. The importance of the trademark in the selection of farm machinery lies in what it stands for.

2. Trade name: It is name by which an article is called or the name given by manufacture to an article to distinguish it as one produced by that company. The use of trade name in the farm equipment industry is being abandoned in fever of model designations.

3. Model: Models in farm equipment may indicate a type of machine, size of an implement or new design of an old machine, special purpose machine or a combination of one or more of these features.

4. Repair: Before considering the purchase of any machine, it is well to look in the source of repairs and spare parts.

5. Design: It is the arrangement of the parts to show the difference of make-up in machine of the same type.

6. Ease of operations: Many implements that look well are found to require an unnecessary amount of power and labor to make them operate successfully. Power and hydraulic lifts have taken the place of the manually operated levers. When the machine has once been properly adjusted, little effort is required from the operator other than steering and turning of machine.

7. Ease of adjustment: In the selection of farm equipment, careful study should be made of the methods for adjusting the various parts. Devices designed to simplify the equipment are time and labor savers.

8. Adaptability to working conditions: There are many implements on the market which are not adaptable to every condition. A machine may work in one locality and be absolute failure in another because it is adapted to certain soil conditions or types of crops grown.

9. Quick change of units: The time and labor required to dismount one

unit and mount are important considerations in selecting farm equipment. Most integral-tractor-mounted equipment is designed for a certain make of tractor and cannot be used on any other make.

10. Maneuverability: As general rule, tractor mounted equipment is provided with power and hydraulic lifts. The units can be lifted and the tractor maneuvered almost as though no equipment was attached.

11. Comfort: As the operator of power equipment must spend days and days riding upon it, the comfort and safety of seat should be considered.

12. Other factors: Other factors to keep in mind in the selection of farm equipment are power requirement, cost of operation, initial cost, years of service expected, and whether the purchase of the equipment is economical in relation to size of the farm and work to perform by the equipment.

2.5.2 Economics of machinery selection

Kay (1981) reported that, the required power level was clearly dependent on both the size of the farm and the nature of duties required of the tractor. Also most significant characteristics of the engine are probably the torque characteristics and the fuel economy.

The basic rule in selection of machinery size is to purchase the machine which will perform the required task within the time available at the lowest possible total cost. This will not always result in the purchase of the smallest machine, as labor and other costs must be considered. A larger machine will have high purchase price and annual fixed costs, but will save labor and reduce field time. Machinery selection may also involve the choice of one larger or two small ones. Purchase cost and annual fixed costs will be higher for two machines, as the same capacity can usual be obtained at lower cost in one large machine than in two smaller ones. Two tractors and two drivers will also needed for tractor-drown equip-

ment. The primary advantage of two tractors is an increasing in reliability. If one machine breaks down, work is not completely stopped but can continue at half speed utilizing the remaining machine, (Kay, 1981).

The determination of the amount of power is similar to determination of the optimum size of the implement. The annual cost (Ac) can be obtained by the following:

$$Ac = (Fc\ \%)\ P + \text{hours of use} \times (R\ \&\ M + L + F + O + \text{timelines})$$

Where:

Fc ≡ fixed cost, ratio of machine price (P).

R & M ≡ repair and maintenance costs.

L ≡ labor cost.

F ≡ fuel cost.

O ≡ oil cost.

2.6 Field Operator Performance

An important component of the economic performance of mechanization system is operator performance. Manager of equipment may be quite knowledgeable about machine and power performance, but unless the machine operator's performance is also high the total system performance may be low, (hunt, 1979). When planning for mechanized agricultural production, the type, amount and quality of operator labor must be considered as well as provision of a safe environment and safety skills as related to equipment operation. The type of labor required for growing crops has changed over the years from a physical role to machine monitoring and machine control role. In present days employment for the farm machine operator may not be physically strenuous but is fatiguing because of the need for continual alertness. The need for alertness increases with size and complexity of machines. Small simple machines may require only steering activities from an operator while the large, complex machines require only a little attention to steering but much more activity

in monitoring the machine operation. Operator labor is changing from an out door to a protected labor. Comfort and protection of an operator from noise, wind, dust and temperature of the field environment is not only thought to be human but economically worthwhile. An operator under the stress of physical discomfort is not expected to be as effective as one who is maintained in a clean comfortable cab. The value of labor for machine operations can be determined in several ways. One obvious evaluation of a method is to portion out the cost of actual hired labor according to hours of time spent operating the equipment. Such a method determines the value of farm labor by having it match off farm labor rates. This is a very realistic way for evaluating hired labor but it is not a too pertinent criterion for the machine operator's wage. Meeting labor competition from other farm enterprises is one way of determining the cost of the machine operator's time. Another method is to consider labor for operating machines not as expense but as an investment with an opportunity for profit (Hunt, 1979).

2.7 Agricultural mechanization in Gezira scheme

Agricultural mechanization was introduced in the scheme from the beginning when implements drawn by bulls and oxen were used for performing cotton ridges and in cultivation of Sorghum. Motorized mechanization dates from around 1930 when the MacLaren system of the cable ploughing and ridging was introduced, and, on a limited scale, Vickers crawler tractors were used for deep ploughing. From the early thirties the mechanization activities of the Sudan Gezira Board were the responsibility of the Ploughs Section of the Department of Mechanical Engineering. During the reorganization of the administrative structure of the Sudan Gezira Board in 1981, this Ploughs Section became the Agricultural Engineering Department (AED) of the Engineering Division. At the same time, a department for Applied Engineering Research, under

the same division, was established, which took over the applied agricultural engineering research duties. Its main activities were the testing of new equipment and development of new machinery and working methods. Besides the AED, two other sectors were engaged in the agricultural mechanization of the Scheme. Private contractors are engaged in number of activities, split ridging for Cotton, cross-ridging, ditching, and green ridging for all crops; primary tillage for crops other than cotton; sowing and harvesting of wheat; some stationary threshing on Durra; and some Ground nut harvesting (Yosif, 1997).

2.7.1 The Agricultural Engineering Dep. (AED)

Traditionally, the main duties of the Ploughs Section were to provide the mechanized field operation for cotton, which at present include deep disc ploughing, dry ridging, application of fertilizer, herbicide spraying for pre-emergence weed control, and ditching. Increasingly, the AED has been called upon to do more because the number of private tractors is not always sufficient to do the work required. Split ridging and inter row cultivation in cotton, and field preparation and sowing of Wheat are among these extra activities. Furthermore, the AED widened the scope of its activities by introducing mechanical Ground nut harvesting some years ago (15000 feddans in 1980/81). While at present, pre-emergence weed control in Ground nut and Durra is being tried on a large scale. At present, the fleet of the AED comprises some 80 crawler tractors another 280 wheel tractors in the 50 – 60kW range, Furthermore, there are large numbers of impalement including 30 ditches blades, disc ploughs, disc harrows, wide level disc, seed drills, fertilizer sprayers, ground nut digger shakers and combine. Included in these figures are 25 crawlers, 90 wheel tractors of 110kW, and 98 wheel tractors of 55kW, together with matching implements which have been purchased recently under the Agricultural Rehabilitation Programme with funds provided by the World Bank.

Among the new machines procured by the department after being privatized, 40 combine harvesters were added to the fleet and a low bed Truck and a Motor grader.

A feature of the organization of the AED is its central management, which means that all the activities are managed from the headquarters in Barakat. The tractors are operated in teams of 10 - 14 tractors under a team leader mechanic who is assisted by two other mechanic and light repairs are done in field by the mechanics of the team. For major repairs and overhauls the machines are brought to one of the workshops of the Maintenance Department in Maringan, Hasaheisa or 24 Gorashi. Communication between headquarters and the team is handled either by the telephone in Group Inspector's office or by car. It may seem remarkable that these activities are managed from one centre, considering the very large area and the long distances involved. However, with the small fleet and with operations, which can easily by planned in advance and further aided by a long tradition, experienced personnel, and a gradual growth, the management performance has been quite satisfactory (Yosif, 1997).

2.7.2 The Private Sector

The Private contractors come from the ranks of the tenants, privet farmers and businessmen. The majority of tenant's contractors own one or two tractors in the 50 – 60kW range used for tillage operations such as ridging. It has proved difficult to gather reliable data on the number of tractors and farm implements owned by private contractors, data obtained on the number of tractors varied from 400 to 1150. The main reason for this variation is that, at the onset of the rains, many contractors move to the rain fed Sorghum areas to help with the soil preparation and sowing. During that rather short period they can earn a much higher income per tractor-hour than in the Scheme. This movement appears to be the main reason for the shortage of tractors in the scheme which, especially during

peak periods, occurs regularly. The data for combine harvesters are more consistent and range between 350 and 400 units.

In recent year, there appeared some big companies with tremendous capabilities and highly advanced machines working in the field of land preparation not only in the Gezira, but for other government and private schemes. For the calculation of machinery requirements, it was assumed that at the start of the rehabilitation project (1983), 350 tractors would actually be available for work in the scheme. In accordance with the machinery decree No. 1155 dated 28th. October 1992, the AED has been privatized; it now works on commercial basis under the administrative umbrella of the Gezira Scheme and a new name, which is Agricultural Engineering Services Company Ltd, (AESC). The steering Committee of the (AESC) embraces in its membership, 4 from the Gezira administration, 3 from the Gezira workers, 3 from tenant's trade union and two persons of high related experience from outside the scheme (Yosif, 1997).

2.7.3 The crop rotation in Gezira scheme

The Gezira Scheme was devised primarily for the cultivation of Cotton. Later because of the value of the irrigated Sorghum to Sudan in years of drought, and the eagerness of the Sudanese farmer to grow his own food crop, area under Sorghum was increased and it was greatly extended by the inauguration of the Sennar Dam 1929. Durra was included with Lubia and Cotton in three -course rotation after Cotton is relatively low. Also, Lubia is harmful to Cotton unless the land is allowed to rest at least one year after it. The introduction of chemical fertilizers and pesticides has made a lot of changes in the agricultural rotation. The fallow land was reduced to the minimum; land has become more fertile for crop production. Also, water from Dams (Sennar & Roseiris) helped a lot with the expansion of agriculture and the intensification of crops in the Gezira Scheme. From 1974 onwards, the area grown with wheat has doubled and so the

area of Groundnuts. The four -course rotation is as follow: Cotton -Wheat Sorghum -Groundnut- fallow. Then when it became of five -course rotation the area for each crop decreased and some area was reserved for fodder production. The main objective of the five -course rotation was to integrate animal production. The five -course rotation as follows: Cotton -Wheat -Sorghum -Groundnuts - fallow -fodder (Yosif, 1997).

2.8. Agricultural Mechanization in the Rahad Scheme

2.8.1 Historical background

The first technical and economical feasibility study of Rahad Agricultural Scheme was made in 1965 by the British expert house (Hunting). The study concluded the weakness of the scheme's economies if happened to follow the same structure and cropping plots heavily applied at the same level on agricultural production in similar schemes. The study concluded the economical feasibility of the scheme on:

1 Increasing production rates in comparison to existing schemes such as Gazira, New Halfa by utilizing better effective farming and production techniques.
2 Intensifying and increase agricultural circle higher than the followed in similar schemes.
3 Renewal of irrigation operations by using better effective farming methods that decrease the risk of crop thirsty or drowning.
4 Avoiding depend on hand labor especially in operations requires large number of laborers like grass removal and harvest.
5 Follow up of Agricultural Research instructions concerning planting time, crops plantation intensity, irrigation rate, grass removal and crops harvest.
6 In the light of these instructions, a decision had been taken to make a pilot farm to conduct applied studies for planning and executing the Rahad Agricultural Scheme, and the World Bank approved the fund

for the scheme (Ahmed, 1990).

2.8.2 The Scheme's Pilot Farm in (Tamboul)

The work started in the pilot farm for Rahad Agricultural Scheme in a location east to Tamboul village on an area of 600 feddan to be irrigated from Algenaid Scheme. The main target of the farm had been to study the possibility of increasing productivity and gain an economic return to indicate future economies of the Rahad Scheme. To reach these goals it was necessary to follow the instructions of the pilot farm as explained above and the use of technologies and farming techniques instructed by the Agricultural Research for increasing productivity. The work in the pilot farm had relayed on constants derived from previous studies like:

1 The concentration from the beginning on the monetary crops cotton and groundnut and planted in a twice agricultural circulation.

2 The use of mechanization in all agricultural operations and comparison to hand labor concerning productivity rates and production cost.

3 Use of long furrow in irrigation (by Hawasha length -300 m. between Abu eshreen) this is to facilitate mechanization operations and grantee better effective irrigation and avoid drowning and thirst.

The operations suggested for test in the farm were as follow:

1. A practical economical method of land preparation for the two crops cotton and groundnut and preparation of long furrows as due to the required standards to facilitate mechanization later.
2. Crop fertilization in conformity to given rates (doses) at the right time by using machine and comparing that to hand labor.
3. Planting by using machine and compare that to hand labor.
4. Removing grass by using machine (herbicides) and hand labor.
5. Harvesting by using machine and hand labor as follow:

A. Ground nut harvest**:**

- Uprooting, collecting and grinding.
- Harvesting by machine.
- Evaluating harvest operation cost, timing loss rates, crop quality and purity in both mechanical and hand harvest.
- Collecting and packing crop remains by using machine.

B. Cotton harvest:

- Hand picking, uprooting stems by hand labor.
- Mechanical picking will be as follow:
- Stopping irrigation measured to plant age and blossom.
- Using falling materials to let leaves fall at the right time.
- Using mechanical pickers in crop harvesting.
- Specification of the effect of mechanical harvest on crop degree and harvest loss.
- Evaluating cost and timing criteria of mechanical harvest operation.
- Using machine in uprooting cotton stems.

Pilot Farm out Come

The results of the applied research conducted in Tamboul farm were sent to the Agricultural Research Corporation in 1972 and was approved. On the light of what had been confirmed concerning Rahad Agricultural Scheme's economies indications the World Bank and other sources agreed to fund the scheme in the year 1973. The most important results were:

1. It had appeared that good preparation of land, deep tillage and seeds bed smoothing is essential requirement for achieving high production rates because of the heavy muddy nature of soil in the area.

2. Long furrow irrigation is practically possible but it requires extreme accuracy in land leveling operations, preparation of straight furrows to avoid thirst and drowning cases, facilitate water flow and machines movement in the field later.

3. Integration of fertilization operations with dries ouster before planting grantees harmony of fertilizers distribution and reduces waste as well as cost.

4. Earlier grass removal within a short period by using mechanical spray with grass disinfectant will provide a better grantee for crop growing in its critical stages.

5. Mechanical planting provides grantees to complete planting timing and attain the required plant intensity because of machine's speed and accuracy in achieving planting operation at the given rates of seeds bedding, dimensions and deepness in addition to machine's smooth pressing on the seed bed in the soil which helps fast and harmonized growth.

6. Ground nut machinery harvest can be done as follow:

   A. Mechanical uprooting of crop 14 days after last irrigation.

   B. Collecting every two lines (furrows) plant in one queue.

   C. Picking uprooted plant rows by using harvester, then separating crop from plant remains and transfer crop to where it should be softened.

   D. Collecting plant remains by using packing by machine to be pressed and packed in bales for other uses.

7. It had been learned that all these operations can be done in two days for every one Hawasha(10 feddans). It was also appeared that mechanical ground nut harvest as explained above will provide many advantages such as:

- Achieves harvest operations in a shorter period and suitable time to commence required planting operations for the next crop.
- Very good crop high cleaning degree.
- Saving of labor need for intensive labor that hand harvest requires like uprooting, grinding and softening therefore ground nut harvest has became no more competing, cotton picking which operation comes at the same time and require intensive hand labor.
- Crop remains can be mechanically packed to be easily transferred in bales and stored for animal feeding.
- Removal of ground nut crop in a shorter time help starting the next crop's planting operations in optimum time.

8. Cotton mechanical harvest requires highly restricted administration so as to grantee stopping irrigation before a suitable time when crop at harvest stage to spray leaves de foil ant to be let fall and start mechanical pickup at the suitable time.
9. Although it eliminates the need for intensive hand labor, it had been learned that cotton mechanical harvest reduces the degree of quality harvested cotton. It appeared that all cottons mechanically harvested and cured at Kassab ginning factory, which is equipped with cleaning machine, had reduced to the third degree, while 75% of cottons harvested by hand was of first degree and 25% of second degree (Ahmed, 1990).

2.8.3 AL-Rahad Corporation

The initial plan as presented in the early studies was based on 84% level of intensification upon which the machinery requirement was based.
Later in the appraisal, report intensification was raised to 100% through a two -course rotation of cropped Cotton and Groundnuts, apart from the areas allotted for horticultural, forestry and animal production. This in-

crease in cropping intensification was not followed by the relevant increase in machinery and maintenance facilities (Ahmed, 1990).

2.8.4 Demand for farm machinery and equipment

The demand for agricultural tractors and farm machinery in general is a derived one in the sense that tractors and their implements are producer durable products that give their services over a period of time ranging between 10-20 years, depending upon proper utilization and upkeep. The demand for tractors in Sudan is determined by major factors:

1. Elasticity of substitution between tractors and labor.
2. Farm size: the bulk of agricultural tractors in the country are demanded by individual farmers representing some 80per cent of total demand the other 20 per cent is demanded by others end users largely representing public and semi public agricultural corporations. To considerable extent, the type of farming, the method of irrigation system, the size of holding and a host of others factors come together to influence the decision to buy or not buy a tractor. The mechanized rain fed represented the greatest single demander of tractors in the country with an estimated market share of 55-60 per cent of total tractors population in the country. The demand for the remaining portion of the market originates in the other agricultural sub sector, namely the irrigated areas under the auspices of public agricultural corporations and individual vegetable and fruit gardens scattered across the country.
3. Investment opportunities through customs hiring: the demand for tractors and implements in this category of end users originates from individual motivated mainly by investment opportunities to custom hire tractors services

2.8.5 Recommended Package:

The recommendations concluded out of the study's results in Tamboul had been summarized as (The Rahad Essential program for Cotton and Ground nut Mechanical Operations) appendix (2). It included the following operations in addition to tillage and softening:

2.8.5.1Cotton

Land preparation

Re-ridging is necessary, particularly in case of long furrow irrigation.

Post crop irrigation for all the area. Disc harrowing for destruction of volunteers and loosing the topsoil. Deep ploughing should be substituted for disc harrowing in areas that are infested with noxious weeds, such as cyndon Dactylon and Cyperus rotundus.

Land smoothing is necessary for long furrow irrigation.

Fertilizer-ridger combination: ridging (80cm) combined with fertilizing (2N) not more than four to five weeks before planting. Beneficial to cotton, application before planting is recommended, in this case, only for its practicability. Pre-watering is carried out after the previous operation above the aim is to help provide a relatively weed free and smooth seedbed therefore, it should be done closer to planting time, about three to four weeks before planting. Hoeing and re-ridging for reshaping of ridges and for weed control. The former is important for long furrow irrigation. This operation is carried out prior to planting (Ahmed, 1990).

Sowing (10-30 July).

Early planting is recommended provided that all weather airstrips are available for early spraying during the rainy season. Otherwise planting should not be earlier than 20 July.

Weed control

Mechanical hoeing supplemented with inter-row hand weeding three to four weeks after sowing. This is repeated two weeks later, and thereafter by sporadic hand weeding whenever necessary during the following three weeks.

Thinning

Can be done after the first weeding operation, three to four weeks after sowing, where diseases and weak plants are removed if necessary. Machine planting needs be reduced, if necessary, to a single plant every 15-20cm within the row, five to seven plants per meter length and hand planting is thinned out to leave three plants per hole every 50cm within the row.

Picking

For efficient picking, the first pick begins when there are a reasonable number of open holes to give a yield of three to four kantars per feddan.The second pick may follow three to four weeks later. About three to four picks can be obtained depending on the condition of the crop. The yield of each pick needs to pack separately.

Disposal of cotton plants (March -mid April).

As soon as the last is picked, the remaining crop should be grazed intensively and thereafter cotton plants uprooted. All cotton stalks, debris bolls, leaves, broken branches, etc, are swept up, heaped and burned. Mechanical root cutting can be practiced but should be carefully supervised to ensure a thorough clean -up operation.

2.8.5.2 Ground nut

Land preparation

- As groundnut follow cotton in rotation, land preparation for it can

only start after the clean -up operation of cotton.

- Re -ridging is essential in the case of long furrow irrigation.
- Pre-watering follows re-ridging and should cover the whole area.
- Hoeing and re-ridging should be prior to planting and about three to four weeks after pre-watering.
- The re -ridging is an essential operation in case of long furrow irrigation and machine planting.

Sowing (15th may -20th June).

Machine planting is recommended if machines are available. Due to long furrow irrigation and machine planting, the crop will be grown on ridges spaced 80cm apart. For machine planting of unshelled nuts, the seed rate will be 120Ib/feddan, shelled nuts in holes 15 cm apart; using two three seeds per hole, with a seed rate of about 40kg.

Weed control (June –July) as cotton and harvesting in (October - November).Avoid stacking or heaping the crop when recently lifted. The mechanically harvested crop should spread uniformly for sun drying for period of four to six days, every day, the spread nuts should be stirred and turned to ensure a thorough and uniform drying. Nuts should not be bagged or heaped before safely drying this will help to minimize the production of Aflatoxin.

CHAPTER THREE

Materials and Methods

3.1 Study Sites

3.1.1 Gezira scheme

The Gezira scheme with area of 2.1 million feddans (0.9 million hectares), is invariably considered as the largest production project in the country, and is internationally recognized as one of the few biggest irrigated schemes in developing countries under one administration. National statistical economic data show that the exports of Gezira Cotton represent 45% of all the country Cotton exports in Sudan. As such the Scheme produces 60%of the Sudanese cotton, 74% of total wheat production, 32% of groundnut production and 12% of the Sudan total sorghum production (Yousif, 1997). In addition it produces vegetables and fruits in an area and enough forage to satisfy the needs of local animal population in the scheme. Wheat was introduced in the Gezira Scheme in early sixties to satisfy the increasing demand for wheat arising from changing of food habits of the population and to improve the farm income of the Gezira tenants.

3.1.2 **New Halfa Scheme**

New Halfa area lays between latitude 15-17º north and longitudes 35-36º East with approximately a length of 115km and width of 30km (Omer, 1986). Topographically the area is flat with few isolated small rocky hills. To overall slope is about 45cm/km from South to North and from East to West direction. The soil is fertile containing 63-65% montmorillonite clay particles, characterized by very high permeability, deep cracking when dry, marked swelling when wet, poor in nitrogen and organic matter. Climatologically, the area lies in the dry climatic zone, with annual

rainfall varying from 200 to 300mm concentrated mainly in July and August. The highest mean daily maximum temperature is 42 Cº in May and lowest mean daily temperature is 14Cº in January. Humidity is low for most of the year and solar radiation is very high. The New Halfa agricultural scheme covers an area of about 410 thousand feddans and the main crops being produced are Cotton and Groundnut.

3.1.3 Al-Rahad Scheme

Al-Rahad Scheme lies at a distance of 160 km south east of Khartoum in the central clay plain of the Sudan. It extended between latitudes 13º43 N and 14º 35´ N and between longitudes 35º55´E and 34º 22´E at an elevation varying between 400.00 - 430.00m above mean sea level. It is about 140km in length and 25 km in width. It lies along the eastern bank of River Rahad, which is a tributary of the Blue Nile, originating from the Ethiopian plateau. The scheme is irrigated by gravity from the river Rahad during the months of June to September. During the rest of the year, irrigation water is diverted from the Blue Nile through pump station into supply canal. The area has semi-arid tropical climate with a humid rainy season extending from June to September followed by a dry period from October to May. The annual rainfall varies from 350 mm in the North to 650 mm in the South .The minimum monthly temperature ranges from 10ºC to 38ºC coinciding with the growing season of the major crops (Cotton, Groundnut, Sorghum and Wheat). However, the highest recorded dry temperature is about 50ºC (Ahmed, 1990).

3.2 Research Methodology

3.2.1 Data collection

The primary data for this study was collected through direct survey, while the secondary data was collected from institutional reports. The main survey was conducted in May 2009 for the collection of quantitative data using a comprehensive questionnaire which was prepared comprising the

information required to satisfy the objective of the study. The data was collected from a sample of 339 involved people including farmers (125), machine operators (70) technicians and engineers (94) via direct individual interviews; in addition, extension workers and other stake holders were contacted. The research is planned to use stratified random sampling and through interviews and structured questionnaire to obtain primary data on farm mechanization, and applied technical packages (tillage intensity and quality, planting harvesting methods) and stakeholders' capacities (Table 4.1). This data is to be supplemented by secondary data from sources including reports bulletins and research studies from the schemes records and other relevant institutions; in addition to books, journal and the internet.

3.2.2Data analysis

The data was analyzed using the statistical package for social sciences (SPSS).

CHAPTER FIVE

Conclusions and Recommendations

5.1 Conclusions:

- In the three National Projects (Gezira, New Halfa and ALrahad) the majorities of the farming community are either illiterate or had only basic education. Such a situation led to difficulties for extension programmes to be effective.
- More than 58% of the three National Projects operator‘s experience ranged between 10-6 and more than 10, this situation adversely affects the efficiency of the responsiveness to research and extension messages.
- There is no organized technical training in the field of agricultural machinery.
- There is a great variation in the adoption of recommended technical packages especially in land preparation, for the different crops.
- Leveling and smoothing were completely removed from land preparation
- Most of agricultural operations in the three National Projects are done manually except for wheat crop where agricultural operations were mechanized.

5.2 Recommendations:

1. A national programme of technical training at different levels and fields of agricultural machinery for different stakeholder including operators and farmers is to be put in place.
2. Considerable attention needs to be given to improving capacities in the use and maintenance of agro–mechanization inputs and criteria needs to be developed to guide the selection of appropriate ma-

chinery systems within the context of a national agricultural mechanization strategy.

3. A national agricultural mechanization strategy should aim at balanced development of the different farming systems covering traditional tools and equipment, animal- drawn technology, as well as engine- powered items.
4. Serious attention needs to be given to problems of operation, stocking of spare parts, repairs, maintenance and training arising from indiscriminate introduction of a great diversity of makes and models of farm machinery.

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CHAPTER FOUR

Results and Dissections

4.1 Education

Table (4.1) Education of involved people (stakeholders)

Stake holder	qualification					Total
	Illiterate	Primary school	Secondary school	Poly tech-nique	University level	
Farmers	12.0%	51.2%	30.4%	0.0%	6.4%	**100.0%**
Operators	2.9%	78.6%	18.6%	0.0%	0.0%	**100.0%**
Technicians	0.0%	24.0%	46.0%	30.0%	0.0%	**100.0%**
Engineers	0.0%	0.0%	8.5%	0.0%	91.5%	**100.0%**
Total	**5.0%**	**38.6%**	**24.2%**	**4.4%**	**27.7%**	**100.0%**

The analysis of the results showed that in the farmer community percentage of illiteracy, in the three schemes was relatively low (12.0 %). 51.2% participated in (khalwa) and received only basic education while 30.4% completed secondary education and 6.4% followed university education, as shown in Table (4.1). These low education levels lead to low perception for research and extension programme, this can be viewed clearly from Tables (4.4, 4.5, and 4.6) where farmers and operators have no information about technical packages.

4.2 Experience

Table (4.2) Experience of stake holders

Stake holders	Experience in years				Total
	less than 3	3-6	6-10	more than 10	
farmers	3.2%	23.2%	44.0%	29.6%	**100.0%**
operators	12.9%	35.7%	38.6%	12.9%	**100.0%**
technicians	8.0%	44.0%	38.0%	10.0%	**100.0%**
engineers	13.8%	33.0%	28.7%	24.5%	**100.0%**
Total	**8.8%**	**31.6%**	**37.8%**	**21.8%**	**100.0%**

The majority 37.3% of machine operators have experience ranging between (6-10) years. 21% have more than 10 years as shown Table (4.2), this experience structure could affect the responsiveness of operators to extension messages. So agricultural education, research and extension programme should be improved to minimize adverse effect of this factor.

4.3 In Service Training

Table (4.3) Qualification (On job Training)

Stake holders	Training courses				Total
	more than 2	2	1	zero	
farmers	3.2%	2.4%	18.4%	76.0%	**100.0%**
operators	2.9%	1.4%	17.1%	78.6%	**100.0%**
technicians	8.0%	8.0%	32.0%	52.0%	**100.0%**
engineers	48.9%	25.5%	20.2%	5.3%	**100.0%**
Total	**16.5%**	**9.4%**	**20.6%**	**53.4%**	**100.0%**

The analysis of the training situation of the different categories in the three National Projects showed a complete absence of organized technical training and severe drain of the old technical skills in the field of agricultural machinery due to immigration. Table (4.3) indicates lack or nearly absence of training programme (24%) of farmer's and (21.4%) of machine operators who are only trained through private companies which

are so limited.

4.4 Land preparation

Table (4.4) Land preparation in Gezira scheme

Operation	Done as rec-ommended	Done but not as recommended	Not done	do not know	Total
primary tillage	0.9%	57.4%	0.0%	41.7%	**100.0%**
smoothing	0.2%	4.0%	54.3%	41.6%	**100.0%**
leveling	0.2%	0.8%	57.3%	41.7%	**100.0%**
Total	**0.4%**	**20.7%**	**37.2%**	**41.7%**	**100.0%**

Table (4.5) Land preparation in Al-Rahad Scheme

Operation	Done as recom-mended	Done but not as recommended	Not done	Do not know	Total
primary tillage	53.7%	26.4%	0.0%	15.9%	**100.0%**
smoothing	50.8%	0.0%	29.3%	19.9%	**100.0%**
Leveling	51.8%	0.0%	27.3%	14.9%	**100.0%**
Total	**54.1%**	**9.1%**	**18.9%**	**17.9%**	**100.0%**

Table (4.6) Land preparation in New Halfa scheme

Operation	Done as recom-mended	Done but not as recommended	Not done	do not know	Total
primary tillage	54.7%	27.4%	0.0%	17.9%	**100.0%**
smoothing	53.8%	0.0%	28.3%	17.9%	**100.0%**
leveling	53.8%	0.0%	28.3%	17.9%	**100.0%**
Total	**54.1%**	**9.1%**	**18.9%**	**17.9%**	**100.0%**

4.4 Land preparation

The Analysis showed great variation in adoption of recommended technical package for the different crops in the three National schemes as per the farmers, machines operators, technicians and engineers. Leveling and smoothing were completely left away due to:

1. High cost of operation
2. Unavailability of implements necessary to perform the recommended

operation.

3. Lack of skilled operators
4. Lack of awareness among farmers

The implement most commonly used is not suitable for land preparation of the reasons for the continuity of this implement as most widely used one is the low input agriculture practiced.

Table (4.4) showed that less than (0.9%) of the recommended package for all crops in Gezira Scheme. This due to the lack of research activities efficient machines and lack of coordination between the research institutions and the Schemes and 41% do not know if it was recommended or not, this due to lack of sufficient training for farmers, engineers, and machinery replacement policy.

Table (4.5) showed in ALRahad the recommended package the absence of watering; most land preparation is done on dry land, resulting in poor machinery performance and high rates of wear and tear. Due to such competition for machinery between the two crops, certain operations were completely a (land leveling, re ridging and hoeing).

4.5 Mechanization of farm operators

Table (4.7): farm operations in Gezira scheme

Mechanization level					
operation	**mechanized**	**semi mecha-nized**	**manual**	**Not done**	**Total**
seeding	18.9%	1.1%	79.9%	0.0%	**100.0%**
fertilizing	16.5%	13.3%	15.7%	54.5%	**100.0%**
spraying	19.3%	8.9%	18.8%	53.0%	**100.0%**
harvesting	26.9%	19.9%	53.2%	0.0%	**100.0%**
Total	**20.4%**	**10.7%**	**41.9%**	**26.9%**	**100.0%**

Table (4.8) farm operations in Al-Rahad scheme

Mechanization level					
operation	**mechanized**	**semi mechanized**	**manual**	**Not done**	**Total**
Seeding	25.0%	66.5%	8.5%	0.0%	**100.0%**
fertilizing	47.2%	0.0%	22.2%	30.7%	**100.0%**
spraying	47.2%	44.3%	0.0%	8.5%	**100.0%**
harvesting	25.0%	69.3%	5.7%	0.0%	**100.0%**
Total	**36.1%**	**45.0%**	**9.1%**	**9.8%**	**100.0%**

Table (4.9) Operation in New Halfa Scheme

Mechanization level					
operation	**mechanized**	**semi mechanized**	**Manual**	**Not done**	**Total**
Seeding	25.0%	66.5%	8.5%	0.0%	**100.0%**
fertilizing	47.2%	0.0%	22.2%	30.7%	**100.0%**
spraying	47.2%	44.3%	0.0%	8.5%	**100.0%**
harvesting	25.0%	69.3%	5.7%	0.0%	**100.0%**
Total	**36.1%**	**45.0%**	**9.1%**	**9.8%**	**100.0%**

The analysis of mechanization situation for different crops in the three schemes showed that all operation done manually many factors contributed, to scaling up of mechanization problems

- Lack of maintenance facilities.
- Unavailability of fast moving spare parts.
- Shortage of agriculture machinery to cover the largest areas.
- Difficulty to secure budget to cover the operating cost of machinery.
- Shortage of technical staff and skilled worker.

Seeding:

As in Table (4.7) about 75 % of all crops, planting done manually and there is lack in sowing implement in the three schemes for all crops. The solution to the sowing problem to be included in the complete mechanization package, planters that can sow in rows to the recommended depth at the recommended rate, covering the seeds and compacting soil around the seeds, taking into consideration the sectors farmer standard, the available skills and know how, it advisable and more practical to shift the farmer to that level through an intermediate stage. This stage could be done through introduction of seed drills which can do all previously mentioned tasks but to lesser degree of precision compared to the planter. Sowing in rows is a prerequisite for effective mechanical weed control. The Analysis showed that fertilizing operations and spraying mainly done manually or semi mechanized or not done as in showed in tables (4.7, 4.8, and 4.9).

Harvesting

The analysis showed that cotton, sorghum and groundnut harvesting mainly done manually tables (4.7, 4.8, and 4.9).

After the schemes faced with serious crop in the first because of shortage of labor, cotton pickers were procured after a lengthy study of technical, economical and social factors ,when the price of cotton was fairly adjusted, the family labor were attracted to the job and the machine were

standing idle.

Sorghum harvesting

Most farmer in the three schemes grow non-combinable varieties of Sorghum so farmers and hired labor cut the sorghum heads, pile them in heaps and use self –propelled combine to thresh the heads.

Groundnut harvesting

The combine harvesting of ground nut was faced with the following:

- The time available to complete the operation is short
- Moisture content of the clay soil to facilitate digging is limited
- Response of the farmers to the operation was not favorable

Wheat harvesting

Start in March after the sign of maturity appear. Harvesting is performed using combine harvesters.

Appendices

Appendix (1)

Machinery energy requirement at 4.8m/h speed

Some machinery energy requirement at 4.8km/h speed	
Energy, KW. h.ha -1	Machinery
8.7-17.5	Plow, moldboard or disk (18cm depth) light soil
14.6-25.8	Plow, moldboard or disk (18cm depth) medium soil
22.1-46.1	Plow, moldboard or disk (18cm depth) heavy soil
7.4-16.1	Vertical disk plow (8-13 cm deep)
4.8-12.5	Lister, hard ground (1m spacing)
10.1-15.7	Subsoiler (40cm deep, 2cm spacing) light soil
12.2-31.3	Subsoiler (40cm deep, 2cm spacing) medium soil
8.1-36.9	Land pane
2.4-12	Chisel plow (18-23cm deep)
2.0-4.0	Field cultivator(8-13cmdeep)
4.0-7.4	Desk harrow light tandem
7.4-12.9	Desk harrow heavy tandem
4.0-7.4	Desk harrow single gang
0.7-2.4	Spike-tooth harrow

Appendix (2)
Deviations from the recommended operation (Al-Rahad scheme) 1987

Initially proposed sequence	**Modified sequence**	**Remark**
Impracticality of post watering Very small scale due to heavy machinery shortage Fertilizer application time changed to after planting Depends on rainfall Because of machinery shortage Mechanical	1/Heavy disc harrowing 2/Light disc harrowing Land leveling with medium land planes 3/Ridging Split ridging (partial) Herbicide application Fertilizer broadcasting Green ridging Boarder disking Abu ×× and Abu vi ditching	Re –ridging Post harvest watering Disc harrowing (light) Land smoothing Ridging (Fertilizer –Ridger) Pre watering Hoeing –re-ridging Mechanical planting Mechanical weeding Cross ridging Abu ×× and Abu vi ditching
Deleted (1984) Delayed cotton picking result in poor working condition (dry) Light rotation (short period available) Shortage of machinery Shortage of machinery (threshing) Poor working conditions (moisture) and tenants.	re –ridging (shaping) boarder disking Abu ×× and Abu vi ditching Mechanical harvest Boarder disking Abu ×× and Abu vi ditching Mechanical harvest (partial)	Cotton stalk cutting Re- ridging Pre watering Hoeing –re- ridging Mechanical planting Mechanical weeding Cross ridging Abu ×× and Abu vi ditching Mechanical harvest

Appendix (3)
Gezira

Ş̲orghum: Area planted, harvested, production &yield(Gezira **)**

Area 1000 / fed Production 1000/ ton Yield kg/ fed

Year	Area			Production	yield
	planted	harvested	Not harvest		
1988/87	466	443	23	244	551
1989/88	441	419	45	264	630
1990/89	464	441	23	238	540
1991/90	507	507	0	254	501
1992/91	709	704	5	462	656
1993/92	622	619	3	430	695
1994/93	547	525	22	386	735
1995/94	469	467	2	327	700
1996/95	394	385	9	271	704
1997/96	409	405	4	465	1148
1998/97	414	353	61	342	969
2000/99	363	300	63	234	780
2001/00	509	500	9	449	898
2002/01	766	728	38	655	900
2003/02	446	433	13	424	979
2004/03	398	363	35	261	719
2005/04	434	409	25	379	927

Source Ministry of Agriculture and Forests

Appendix (4)
Gezira

Wheat: Area planted, harvested, production &yield

Area 1000 / fed Production1000 / ton Yield kg / fed

Year	Area			Production	yield
	planted	harvested	Not harvest		
1988/87	253	245	8	123	502
1989/88	282	274	8	164	599
1990/89	404	392	12	235	599
1991/90	631	612	19	334	546
1992/91	532	527	5	495	939
1993/92	514	500	14	280	560
1994/93	523	523	0	277	530
1995/94	393	384	9	230	599
1996/95	400	391	9	254	650
1997/96	390	385	5	270	701
1998/97	320	301	19	261	867
1999/98	176	125	51	34	272
2000/99	67	43	24	22	512
2001/00	116	111	5	100	901
2002/01	80	80	0	58	725
2003/02	116	111	5	100	901
2004/03	200	190	10	171	900
2005/04	149	142	7	114	803
2005/06	156	153	3	122	800
2006/07	300	293	7	264	900

Source Ministry of Agriculture and Forests

Appendix (5)
Gezira

Cotton: Area planted, harvested, production & yield

Area 1000 / fed Production1000 / ton Yield kg / fed

Year	Area			Production	yield
	planted	harvested	Not harvest		
1988/87	403	383	20	248	648
1989/88	425	404	21	301	745
1990/89	377	358	19	209	584
1991/90	252	249	3	124	498
1992/91	216	216	0	155	718
1993/92	177	175	4	99	566
1994/93	152	149	3	76	510
1995/94	255	252	3	153	607
1996/95	311	299	12	179	599
1997/96	348	335	13	170	507
1998/97	252	241	11	160	664
1999/98	223	162	61	106	654
2000/99	297	259	38	99	382
2001/00	200	200	0	135	675
2002/01	200	200	0	103	515
2003/02	248	248	0	169	681
2004/03	284	250	34	178	712
2005/04	326	297	29	209	704
2005/06	244	222	22	156	705
2006/07	188	171	16	121	710

Source Ministry of Agriculture and Forests

Appendix (6)
Gezira

Groundnut: Area planted, harvested, production &yield

Area 1000 / fed Production1000 / ton Yield kg / fed

Year	Area			Production	yield
	planted	harvested	Not harvest		
1988/87	165	159	6	127	799
1989/88	115	111	4	111	1000
1990/89	83	80	3	56	700
1991/90	42	36	6	32	889
1992/91	35	35	0	26	743
1993/92	168	165	3	146	885
1994/93	187	178	9	149	837
1995/94	191	187	4	159	850
1996/95	240	231	9	231	1000
1997/96	244	242	2	242	1000
1998/97	251	223	28	212	951
1999/98	202	158	44	126	797
2000/99	205	164	41	113	689
2001/00	171	162	9	123	759
2002/01	45	43	2	36	837
2003/02	160	150	10	150	1000
2004/03	132	124	8	127	1024
2005/04	127	120	7	120	1000

Source Ministry of Agriculture and Forests

Appendix (7)
Al-Rahad scheme

Groundnut: area planted, harvested, production & yield

Area1000fed production1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	63	61	2	49	803
1989/88	67	65	2	52	800
1990/89	56	54	2	43	796
1991/90	52	52	0	62	1192
1992/91	65	62	3	59	952
1993/92	72	70	2	53	757
1994/93	70	67	3	67	1000
1995/94	68	63	5	50	794
1996/95	68	66	2	53	803
1997/96	68	67	1	57	851
1998/97	61	60	1	55	917
1999/98	45	26	19	10	385
2000/99	64	63	1	52	825
2001/00	55	54	1	41	759
2002/01	32	30	2	27	900
2003/02	31	31	31	0	1000
2004/03	29	20	9	20	1000
2005/04	40	40	0	44	1100

SourceMinistryofAgricultureandForests

Appendix (8)
Alrahad scheme

Sorghum: area planted, harvested, production & yield

Area1000fed production1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	66	63	3	32	508
1989/88	73	69	4	35	507
1990/89	76	72	4	43	597
1991/90	95	95	0	85	895
1992/91	96	95	1	94	989
1993/92	74	73	1	46	630
1994/93	75	71	4	60	845
1995/94	69	66	3	63	955
1996/95	68	66	2	63	955
1997/96	71	70	1	106	1514
1998/97	100	100	0	105	1050
1999/98	116	78	38	39	500
2000/99	93	85	8	43	506
2001/00	110	100	10	105	1050
2002/01	147	140	7	154	1100
2003/02	77	76	1	74	974
2004/03	78	77	1	42	545
2005/04	80	78	2	86	1103

Source Ministry of Agriculture and Forests

Appendix (9)
New Halfa

Sorghum: area planted, harvested, production &yield

Area 1000fed production 1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	32	29	3	12	414
1989/88	88	80	8	40	500
1990/89	70	64	6	29	453
1991/90	86	86	0	46	535
1992/91	153	132	21	73	553
1993/92	62	61	1	24	393
1994/93	30	25	5	10	400
1995/94	74	68	6	35	515
1996/95	61	51	10	24	471
1997/96	68	67	1	41	612
1998/97	69	60	9	50	833
1999/98	60	55	5	44	800
2000/99	53	52	1	36	692
2001/00	60	49	11	37	755
2002/01	75	65	10	64	985
2003/02	57	52	5	47	904
2004/03	65	62	3	59	952
2005/04	57	50	7	29	580

Source Ministry of Agriculture and Forests

Appendix (10)
New Halfa

WHEAT: area planted, harvested, production & yield

Area1 000fed production 1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	35	33	2	15	455
1989/88	58	54	3	32	593
1990/89	75	70	5	49	700
1991/90	88	82	6	48	585
1992/91	64	62	4	44	710
1993/92	62	53	9	31	585
1994/93	67	62	5	22	355
1995/94	59	45	14	23	511
1996/95	55	52	3	31	596
1997/96	63	61	2	35	574
1998/97	58	57	1	40	702
1999/98	54	46	8	18	391
2000/99	14	14	0	7	500
2001/00	5	5	0	3	600
2002/01	24	24	0	15	625
2003/02	5	5	0	3	600
2004/03	20	20	0	14	70
2005/04	6	5	1	3	600

Source Ministry of Agriculture and Forests

Appendix (11)
New Halfa

Groundnut: area planted, harvested, production &yield

Area 1000fed production 1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	25	23	2	17	739
1989/88	39	36	3	22	611
1990/89	24	22	2	18	818
1991/90	39	39	0	6	154
1992/91	44	37	7	29	784
1993/92	51	50	1	29	580
1994/93	36	36	0	31	861
1995/94	48	45	3	50	1111
1996/95	49	47	2	38	809
1997/96	48	45	3	39	867
1998/97	46	43	3	43	1000
1999/98	36	35	1	32	914
2000/99	45	45	0	53	1178
2001/00	46	46	0	41	891
2002/01	35	33	2	45	1364
2003/02	28	26	2	31	1192
2004/03	31	30	1	32	1067

Source Ministry of Agriculture and Forests

Appendix (12)
New Halfa

Cotton: area planted, harvested, production &yield

Area1000fed production1000ton yield kg/fed

Year	Area			Production	Yield
	planted	harvested	Not harvest		
1988/87	78	76	2	46	455
1989/88	62	60	2	25	593
1990/89	78	76	1	49	700
1991/90	52	50	2	20	585
1992/91	41	41	0	27	710
1993/92	41	40	1	20	585
1994/93	50	50	1	25	355
1995/94	52	50	2	32	511
1996/95	61	60	1	28	596
1997/96	60	58	2	26	574
1998/97	50	45	5	25	702
1999/98	40	37	3	21	391
2000/99	45	41	4	21	500
2001/00	40	40	0	23	600
2002/01	40	40	0	28	625
2003/02	38	37	1	26	600
2004/03	38	38	0	15	70
2005/04	50	45	5	21	600

Source Ministry of Agriculture and Forests